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Building the Tramway Over Chilkoot Pass.

BY W. A. BURKHOLDER.

BUILDING an aerial tramway over Chilkoot Pass, or rather, to speak more accurately, the building of an aerial tramway *up* the Chilkoot Pass from the foot of the canyon to Scales, at the summit of the mountain, is an engineering problem of expedients and frontier experiences, rather than of technical detail. To begin with, the work was of the variety best known as a "rush job," but to make matters more interesting, the contract was executed in the depth of an Alaskan winter, with labor mildly characterized as "unskilled," and in a country where the monotony of having different parts, if not the entirety, of one's anatomy frozen, was varied only by the excitement of death dealing avalanches. Labor —spare the mark!—cost $3.50 to $5 a day and board. At times it was necessary to dig through twenty feet of snow before reaching the ground, and then, particularly during the last two miles of the line, the ground proved so hard that it was almost impossible to break it with dynamite, to say nothing of the difficulty, if not the impossibility, of thawing the explosive. It was at all times necessary to put the poles into the holes as soon as the latter were dug, or otherwise the holes would quickly fill with drifting snow. As to the weather, that at the foot of the summit is of a severity I cannot describe. It is with the greatest difficulty, at times, that one can stand up against the hurricane that blows there, and this, with a temperature perhaps far below zero, makes it almost impossible at times for human beings to exist there for any length of time. Both my cheeks were frozen one morning while making an inspection of the line, and a few days before, the hard frozen bodies of two Indians were taken from the trail. It was below this point that occurred the great avalanche of February last, wherein nearly sixty adventurous gold-seekers were buried alive, and which was so fully reported in the daily press at the time. Although the great avalanche crossed the pole line of the D.-K. T. Co.'s tramway, it did not injure it beyond tearing down a few stretches of wire. Nevertheless, the work on the tramway, which was begun on June 15th last, was completed on March 20th, when it commenced operations. The original plans for the building of the tramway of the Dyea-Klondike Transportation Company contemplated the erection of a power house, to be driven by steam, at Dyea, and an eighteen-mile transmission thence to Scales, at the foot of the Pass. This transmission was to be at 5000 volts, three-phase, with step-up and step-down transformers, and the equipment for it reached Dyea in January. On arriving on the ground, however, I advised against the transmission as proposed from Dyea, when the power house could be both installed and operated as cheaply and as satisfactorily at the mouth of the canyon as at Dyea. Some eleven miles of transmission line, as well as the raising and lowering transformers and all attendant losses would be obviated should the change be effected, and, accordingly, the power house was located at the mouth of the canyon.

LENGTH, 4000 FEET.
GRADE, 30 PER CENT.

A STRING OF HUMANITY
CLIMBING CHILKOOT PASS.

The generating station is a plain log building measuring

20×60 feet, and the steam equipment placed therein consists of a 16-foot by 64-inch marine type boiler, and an 11×12 inch automatic engine, from which is belt-driven a Westinghouse 45 kilowatt, two-phase generator, delivering 2000 volts. The station contained no "frills," but the behavior of the boiler is worthy of special mention. It was of the marine type, designed for burning coal under forced draught, but no coal was to be had. The only wood available was green hemlock, at $5.50 per cord, and while we did succeed in getting up steam, I have often thought that it was due to the sulphurous heat of the fireman's outbursts of wrath, more than to any calorific virtue of the wood itself.

Canyon City is nine miles above Dyea, which is the seaport for those who go to Dawson and the Klondike by the most direct route. The distance from Canyon City to the foot of the Pass is a little over seven miles, and along this distance the pole line passes, thence up the canyon to Scales. The poles are of thirty-foot spruce, cut from the mountain side, and measure from six to eight inches in diameter at the top, to from ten to twelve inches at the butt. In the canyon the line is run in the most direct route possible, the poles being set in holes blasted out of the solid rock, and so that the line runs from point to point along the side of the canyon. This pole line carries only the two-phase transmission circuit, consisting of four No. 6 B. & S. guage hard drawn copper wires, supported on Locke triple petticoat glass insulators, on wood topped steel pins. The transmission line is barreled twice in its length, and the poles also carry a telephone circuit.

The motor house at Scales contains a step-down transformer which reduces the line potential to 200 volts for driving a Westinghouse fifteen horse-power induction motor (type "C"). The motor is belted to a shaft operating winding drums through clutches, so that one of the drums takes up the cable while the other pays it out at the same speed. The outfit is a regular mine hoist, and was, in fact, taken from the Sheep Creek Mine near Juneau. The length of the cable, which is, of course, double, is about 4000 feet, and the greatest single span is approximately 3000 feet in length. Loads varying from 1200 pounds to 1500 pounds are carried with ease up grades running as high as thirty per cent., and some parts of the tramway run along the side of the canyon from 500 to 600 feet almost vertically above the trail. It should be explained that the "D.-K. T. Co." tramway, which is now being described, consists of a traction cable of five-eighths inch plow steel, supported at intervals as close as possible, on staunch overhanging pole structures. On these traction cables run, or rather underrun, two buckets, not unlike two coal conveyors joined together, and these buckets are hauled along the traction cable by means of a pulling cable, also of plow steel, but having a diameter of one half an inch. It is this latter cable that is wound on one or the other of the two drums referred to, according to whether the buckets are being raised or lowered. The tramway, which is 4000 feet in length, is used only for freight, although employees have been over it often, and one young lady, a Miss Edgerton, who is a Red Cross nurse, made the perilous trip in safety shortly after the completion of the tramway. She was the first and only woman who ever went over the trip, despite the full page story in a New York Sunday paper describing, with thrilling attributes, the journey as made by one of its women reporters. The tramway is capable of handling fifty tons of merchandise daily, and the cost for the service is ten cents per pound from Dyea to Lake Linderman, which is a cut from the rate of forty cents which existed for the same service last fall. The rate for the 4000 feet of the Pass alone is one cent per pound.

PACKING OUTFITS.—BEFORE THE COMPLETION OF THE TRAMWAY.

So great was the activity of the transportation companies during last winter, that by the commencement of the season this summer, three different tramways were in operation over the Chilkoot. In addition to the one described, the Alaska Railway and Transportation Company were operating a single one-inch cable between the top of the hill above Stone House to the top of the mountain overlooking Crater Lake. This cable has a length of about 7000 feet and is run by a forty horse-power gasoline engine. The third system is known as the "Bleichert system," and uses a steam plant for operating its tramway from Canyon City to Sheep Camp, and another for that

section from Sheep Camp to the Summit. These three systems were consolidated early last summer, and now only the Bleichert system is in active operation. As might be supposed, life in Alaska during the memorable winter of

SEVENTEEN LASHES FOR THIEVERY.

1897-98, bristled with startling experiences, one of which is brought out in the photograph of one of the towers supporting the traction cable on the Chilkoot tramway. This tower is at Sheep Camp, and the animated scene just beneath the tower shows a method of administering justice *a la frontier*. Two men were convicted by a committee as being guilty of stealing provisions from different outfits along the trail. A committee of five was appointed to determine on the punishment to be inflicted, and of the committee, two stood for lynching and three for public lashing. One of the thieves, fearing lynching, committed suicide by shooting himself through the head; the other was stripped to the waist and tied to the pole as shown, after which he was given seventeen lashes with a "cats' tails" of half-inch ropes, when a doctor interfered and stopped any further punishment. The crowd then placarded the trembling wretch: "Thief; pass him along," and marched him under guard to Dyea, fourteen miles distant.

Charcoal much purer than coke, and therefore better suited for making calcium carbide than the former variety of carbon, is, it is claimed by a contemporay, being produced from sawdust by the use of retorts.

Steam

COAL COMBUSTION AND SMOKE PREVENTION.*

BY JOHN L. HOWARD.

THE problem of the prevention and abatement of smoke in the combustion of coal has long occupied the attention of chemists, mechanics, and inventors. For public and economic reasons the solution of this problem has been attempted in a variety of ways, and with varying measures of success. During recent years, however, the subject has assumed new importance as a public question in many Eastern cities, where smokeless fuels hitherto used in manufactories have been displaced by those that produce smoke, and the demand for a remedy has arisen from the owners of buildings that are threatened with soot discoloration, and from the public officials having regard for the appearance and health of their cities.

It may serve a good purpose if we take a brief and hasty survey of the character and composition of fuels, of the wonderful chemical operations that take place in the process of combustion, of the elements that are involved in it, and of the conditions that favor its completeness.

In commercial fuels we have examples of the three states of matter:

Solid—As in coal and wood, where the force of attraction binds together the molecules.

Gaseous—As in artificial or natural gas, where the repellant force separates the molecules.

Liquid—As in petroleum, where the two forces act in equilibrium.

These different forms of carbon, or of combinations with it, constitute the supply from which is obtained the material to produce light and heat.

In the consideration of coals, it will be found that there are two commercial divisions:

CACHEING SUPPLIES AT SUMMIT.

1. The anthracites, which are distinguished chemically by the presence of much fixed carbon and but little volatile matter.

*A paper read before the Sixth Annual Meeting of the Pacific Coast Gas Association, San Francisco, July 20, 1898.

They vary in quality within narrow limits, and are practically smokeless.

2. The bituminous, which grade into the anthracite condition, and are made to comprehend all below that down to the lower order of lignites.

Therefore, these have a larger range of quality. They have in less degree what anthracites have in abundance, viz.: fixed or non-volatile carbon, and they have a high percentage of volatile matter which is very low in anthracites. It is this difference which makes the general distinction between the anthracite and bituminous grades.

Let us look for a moment into the method employed to determine the constituents of coal and their quantative relations. A pulverized sample is accurately weighed and subjected to a heat of 212° F., until the weight becomes constant. The loss or the difference between this and the original weight indicates the amount of *moisture* that has been expelled. The crucible is then covered and the heat is greatly increased until the weight again becomes constant. The loss, or the difference between this and the preceding weight, indicates the amount of *volatile matter* that has been driven off; the balance is coke. When this has been burned a reweighing will indicate the amount of *fixed carbon* that has been consumed, as well as the remaining incombustible matter or *ash*.

This method of proximate analysis is the determination of contents by weight differences, giving the moisture, ash, fixed carbon and a chemically complex body called volatile matter, consisting chiefly of hydrogen and carbon in combination, oxygen and sulphur. It is this wonderful complex body that has special interest in this discussion.

We are now able to understand the cause for the great variations of quality in coals, due to the differences in the proportions of constituent parts, as may be more clearly shown by the following table of analyses of a few typical coals:

	Bituminous.		Anthracite.	
	Lignite, Seattle.	Australian.	Pennsylvania.	Welsh.
Moisture	7.	2.52	2.50	.96
Volatile matter	31.75	30.57	2.224	5.82
Fixed carbon	58.25	61.05	90.276	90.63
Ash	3.	5.86	5.	2.59
	100.	100.	100.	100.

For the interest that it may have, I quote from "Wagner's Approximated Tables," showing the chemical alteration that has taken place in the progress from the lower to the higher forms of fuel:

	Carbon.	Hydrogen.	Oxygen.
Wood	52.65	5.25	42.10
Peat	60.44	5.96	33.60
Lignite	66.96	5.27	27.76
Bituminous	76.18	5.64	18.07
Semi-anthracite	90.50	5.05	4.40
Anthracite	92.85	3.96	3.19

While this table shows the total of the fixed and free carbon, yet it indicates that in this progress there has been a constant decrease in the volatile matters until the highest condition is reached in the anthracite stage. We may now leave this preliminary survey of fuel composition, bearing well in mind that the elements concerned in combustion are: First, in anthracites, the fixed or non-volatile carbon, which ranges from 85 to 90 per cent. of the mass; second, in bituminous, the fixed carbon and also the hydrocarbons contained in the volatile matter, remembering also that moisture, oxygen, and ash are not concerned in it, and that the intrinsic value of the fuel is affected in the proportion that they exist.

We now come to consider the question of combustion, which is due to the chemical combination of atmospheric oxygen with the combustible elements contained in the fuel.

Chemistry has determined that 29.86 cubic feet of oxygen per pound of carbon, or two volumes of oxygen to one of carbon, are needed to produce carbonic acid gas, resulting from the *complete* combustion of carbon; that 89.6 cubic feet of oxygen per pound of hydrogen, or one volume of oxygen to two of hydrogen are needed to produce water, resulting from the *complete* combustion of hydrogen; and that 11.2 cubic feet of oxygen per pound of sulphur, or two volumes of oxygen to one of sulphur, are needed to produce sulphuric acid, resulting from the *complete* combustion of sulphur.

This relation of oxygen to combustibles is fixed and definite. If less be furnished the combustion will be partial; if an excess be furnished the combustibles will appropriate what they need and the detrimental surplus will pass away. Atmospheric air contains about 21 per cent. of oxygen.

Knowing this, and knowing also the chemical composition of any fuel, it will be seen that the amount of air needed for its combustion is calculable.

For example, a coal containing 90 per cent. carbon, 5 per cent. hydrogen, 3.5 per cent. oxygen, 1 per cent. nitrogen, and .5 per cent. sulphur, would require 143.98 cubic feet of air per pound, or 322.515 cubic feet of air per ton, of coal.

It follows, therefore, that, unless sufficient air carrying oxygen shall be brought into contact with the carbon and hydrogen to produce carbonic acid gas and water, the combustion will be incomplete and there will be a loss of heat energy.

Let us follow in part the chemical and physical changes that occur in the consumption of bituminous coal. When a charge of fresh coal is thrown on the fire the first effect is to lower the temperature of the furnace, because of the cold air that is drawn in through the open fire door, and because new coal at the atmospheric temperature (say 60° F.) is fed upon a bed of coals, the temperature of which may vary from dull, red heat, (say 1300° F.) to bright, white heat (say 2500° F.) The sudden reduction of furnace temperature is not conducive to chemical union at this critical point.

The distillation of volatile matter begins almost at once, and it has been found that, at a temperature of about 1100° F., most of the coal gases will ignite if the oxygen be present.

When the distillation process is completed, then the operation in the fire is the combustion of the fixed carbon, which is combined with the incombustible matter in the coke. The oxygen rushes to the carbon as it is exposed on the surface of the incandescent lumps and continues the attack until they are reduced to ashes. The product now is either carbon monoxide or carbon dioxide, according to the completeness of the process. It will be noticed that heat is essential and that the combustion will be intensified as the supply of oxygen is increased.

This burning of bituminous coke after the volatile products are driven off, is the same operation that consumes anthracite coal and artificial coke. It is the combustion of the fixed carbon, and the products are not visible.

Smoke may be called the *visible* part of the products of combustion. We have seen that it does not occur in the burning of anthracite nor in the consumption of the coke portion of a bituminous fire. We are, therefore, able to say that it is generated during the distillation of the volatile matter contained in bituminous coal, and it is due to the imperfect combustion of those gases. The ingredients chiefly concerned are the hydrogen and carbon. It has been found that the hydrogen constitutes only five or six per cent. of the coal constituents, and that oxygen has for it a stronger affinity than it has for carbon. We, therefore, conclude that some of the volatile carbon when in the gaseous state is not consumed, but is condensed or precipitated into the solid condition of soot, and we may further assume that this change from the gaseous to the solid condition will result from any of three causes: First, an insufficient supply of oxygen to consume the volatilized carbon of the coal; second, a want of thorough contact between that and the oxygen; third, unfavoring temperature conditions for the quick and complete combination of the oxygen and the volatile carbon.

It is upon these lines that inventors have worked to produce devices looking to the prevention of smoke.

It must be remembered that the *commercial* loss in the prevention of smoke itself, great as it may at times appear to the eye, is really unimportant, for the experiment has shown that bituminous coal, burned under very unfavorable conditions, yielded in soot only about one-half of one per cent. of the weight of the coal tested, and an analysis of the soot shows the actual loss to be immaterial. Far greater losses may be suffered in products that are not visible, for if the carbon be turned into carbon monoxide a heating power measured by 4500 British thermal units per pound of carbon is obtained; whereas, if the process be not arrested, and this gas, by the addition of one atom of oxygen, can be converted into carbonic acid gas, the resultant heat will be 14,500 British thermal units, or more than threefold.

The difference between the steam and gas men is, therefore, readily seen. In water gas making the struggle is for carbon monoxide, that erstwhile nightmare of our local journals, while in steam making the effort is to push the process on to carbon dioxide, a product which, to the gas man, is worse than useless. Again, in coal gas making, the method of destructive distillation employed is different only in so far as that air is excluded. The gas man finally burns his hydrocarbon through a jet under proper heat, and where the supply of supporting oxygen is abundant for perfect combustion of the gas, but the steam man finds it difficult to maintain the needed constant furnace temperature and to regulate the supply of air to meet the varying calls for oxygen during the process of volatilization.

The cry for relief has brought forth anti-smoke ordinances in such cities as Chicago, Cincinnati, Cleveland, Pittsburg, St. Louis, Detroit, Milwaukee, and Minneapolis, and like measures are under consideration in other cities. There seems to be only a half-hearted enforcement of such laws; in fact, the Chicago ordinance remained passive until an associatian of citizens took steps to compel an observance. History shows that London, which has suffered more than any other city of the world, sought legal relief 600 years ago, when the use of bituminous coal was made a capital offence. There have been spasms of legislation since that time, and still she suffers. The situation is greatly aggravated there, because of the hundreds of thousands of household chimneys that are contributing to pollute the atmosphere, and the domestic hearths are not as amenable to treatment as are the boiler furnaces of manufactories.

While the use of anthracite coal is spreading in England it will take much time to divert the trade from the long used bituminous coals, as indeed it would be diffcult to turn the household demand of the Atlantic seaboard from the anthracite.

The anti-smoke legislation in this country has had the effect, however, of greatly increasing the number and kind of devices intended to remedy or palliate the evil.

We have the principle of compelling the volatile gases to come in contact with the high temperature of incandescent coal, as is rudely attempted in the hand firing of the two sides of a furnace alternately, or by overfiring and drawing the gases down through a bed of live coals on an underlying grate, as was shown by James Watt, and more recently developed in the Hawley furnace; or by the use of dead plates in the front of the furnace, whereby the gases from the fresh coal would pass over the incandescent matter in the rear; or by pistons which push a body of coal from a front hopper into the furnace; or by underfeeding arrangements, where the fresh coals are automatically fed from an underlying trough and gradually pushed into the furnace, meantime the evolved gases being made to pass through the overlying bed of incandescent coals.

There have been numberless methods of introducing air with and without steam: through vertical perforated plates situated under the bridge wall, through split bridge walls, from the furnace sides in jets from above the furnace doors, through furnace doors, hot air, cold air and saturated air, above and below the fire, are all represented in the patents. The schemes seem to have culminated in what are called automatic stokers, of somewhat complicated and expensive mechanism, intended at one stroke to cover the entire range of involved problems. First, by a mechanical transport of the coal from the bins to furnace hoppers, and an arrangement of feeding on slow moving grates of different types, to reduce the number and cost of attendants connected with coal firing and ash removal; second, to keep an even and high furnace temperature by avoiding the opening of fire doors and the chilling effect of a body of fresh coal when scattered over the fire; third, to admit air in such way and in such quantity as to bring about complete combustion of all the combustible elements in the fuel.

The published experience of those who have used these elaborate systems is not *all* favorable to them.

I may close my paper with the relation of some personal experiences.

The effort to introduce Welsh anthracite smokeless coal as a steam fuel compelled us in some instances to guarantee economy, based upon its evaporative power and its cost as compared with grades of bituminous coal. This brought such knowledge from the tabulation of comparative steam making values that we finally did not hesitate to guarantee that Welsh anthracite, when burned under our system, would evaporate twenty-five per cent. more water than the best grade of Australian steam coal. We never failed in such an undertaking, because, with our method, the anthracite, with adjusted grate area and air space, and with forced draught, was burned under more favorable conditions than was the case with bituminous coal burned under the conventional methods.

This becomes the more apparent when you observe that the total of the heat giving constituents of a good bituminous coal and of an ordinary anthracite are nearly the same, and self-interest prompted a line of experiments to prove whether a bettering of the conditions would not make the combustion of the bituminous coals more complete, and thereby not only prevent the formation of smoke, but also secure the greater advantage of increasing its value by raising it nearer to the standard of evaporative power possessed by the anthracite coal.

After a somewhat careful study of the bituminous coals that come to our market, of their action in the furnace, and of the principles that underlie the classes of patents that have been offered, some experiments led us to observe that beyond the quantity of air and the temperature of the furnace, lay an important factor; namely, the method and the place of administering the air to bring about a thorough contact and union of the oxygen and the combustible elements of the fuel.

It may be stated that, in order to prevent any reduction in furnace temperature through the opening of fire doors, an automatic or other mechanical contrivance is necessary for the feeding of the coal and for the removal of the ashes.

There are comparatively few of the total number of owners of steam plants who recognize the ultimate value of these arrangements looking to economy, or who have the inclination to risk the investment of money in modern appliances. It, therefore, becomes necessary in this field of study, to devise a simple, effective, and not expensive apparatus that may be attached to boiler plants as they exist, without material changes in them.

It may be a matter of surprise to some when I state that, in the experiments to establish the ratios of air to be delivered through the grates and above the fire, the improvement in the evaporative power of the coal continued until we had delivered two and one-half times as much air above the fire as was permitted to pass through the bars from below.

This verified the theory that the proper administration of air had an important bearing upon the combustion of the fuel; for, as compared with the evaporative results obtained from burning the same coal with natural draught on the ordinary bars and under the best conditions, the effectiveness was raised from fifteen to twenty per cent.; and more than this, there was an absence of smoke and only a slight color when a highly bituminous coal was mixed with coal tar.

It will need further and severe testing under all conceivable conditions and with different grades of coal for final proof that the device merits the expectation of its projectors, but it is a long move towards the end for which experimenters have been reaching out and are now working with renewed activity and with greater hope of success.

The most perfect form of fuel is that in the gaseous condition; next in order is the liquid petroleum, when atomized and mixed with its proper proportion of air in the presence of a high temperature.

The highest evaporative power will be obtained from solid fuel when it is pulverized and introduced in the furnace properly admixed with air so that the combustion will be immediate and complete. Then the greatest heat energy will be obtainable, then the smoke will naturally cease; and almost within the grasp of invention is a small, effective apparatus, attachable to the front of a boiler, into which the coal of any size may be mechanically fed, pulverized and delivered into the furnace continuously. This, too, at a cost within easy reach of the owner of steam boilers. When this is achieved there will be no need of prohibitory legislation, because the self-interest of coal users will cause the adoption of economical appliances that in their operations will obviate the smoke nuisance.

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EDITORIAL.

A LOOK INTO THE FUTURE.

The presidential address of Sir William Crookes before the British Association for the Advancement of Science, gives the views of an eminent scientist on the possible part that electricity and kindred interests may play in the civilization of the twentieth century, and from a supposedly disinteresting dissertation on the food supply of the world, he unexpectedly startles electricians with an expression of belief in the probability that the famine in wheat and breadstuffs which threatens coming generations will be averted through the electrical reduction of the free nitrogen of the air into a fixed nitrogen fertilizer that will vastly increase the productiveness of the wheat fields of the world, which, by the way, are rapidly becoming impoverished despite every effort toward its prevention.

According to Crookes, every square yard of the earth's surface sustains about seven tons of free nitrogen in the atmosphere. Were this free nitrogen converted to a fixed nitrogen compound, such as nitrate of soda, and such as is required for fertilizing purposes, its present market value would be nearly $25,000. Only by means of the use of such a fertilizer can the supply of wheat for the world's constantly increasing consumption be maintained. Nature's production of nitrate of soda is limited in quantity and will soon be exhausted. Nature's store of free nitrogen is inexhaustible; it is as bountiful as the air itself, and Niagara alone is capable of producing the electrical energy required to reduce the free nitrogen of the air to the twelve million tons of nitrate of soda annually required to render the world's wheat fields sufficiently productive to fill the granaries during the coming century. The prospect of the installation and operation of the colossal electric plant necessary to fulfill this duty should be an incentive for earnest efforts to discover the means for commercially perfecting the crude laboratory experiment by which a fixed nitrogen compound results from the combustion of atmospheric nitrogen in a static spark. Here is a golden opportunity for investigation, and it is one, moreover, that is fraught with prospective rewards of the highest plane of humanitarianism.

A further surprise in the presidential address rests in the consideration of the resources of molecular movements, which brings out opinions that will be accepted by the general public as chimerical, yet how indicative of the unscientific nature of the public is this doubt! In what other light than that of astonishment, not unmixed with incredulity, will the layman view the statement that, "The total energy of both the translational and internal motions of the molecules locked up in quiescent air at ordinary pressure and temperature is about 140,000 foot-pounds in each cubic yard of air. Accordingly, the quiet air within a room twelve feet high, eighteen feet wide, and twenty-two feet long, contains energy enough to propel a one-horse-power engine for more than twelve hours. The store drawn upon naturally by uranium and other heavy atoms only awaits the touch of the magic wand of science to enable the twentieth century to cast into the shade the marvels of the nineteenth."

IT IS ORIGINAL, UNDOUBTEDLY.

The attitude of some electrical contemporaries in matters pertaining to electrical transmission surpasses understanding. Last month occasion was given to refer to the absurd stand taken by a New York journal upon the utility of glass insulators for transmission purposes, and now a still more prominent publication gives a place of honor to a communication to which is given, evidently in thoughtlessness, the serious title, "Proposed Method of Long Distance Transmission." The proposed method, concisely stated, is to insert a transformer having a ratio of 1 to 1, in the transmission line midway between the generating and receiving stations, then, to quote the article itself, "if the current in the first section has a tension of 25,000 volts, the current in the second section will have a tension of nearly 25,000 volts."

The fruits of this suggestion, as the writer presents them, are not disillusionizing, as he states that "it will now be seen that by this method it should be practicable to transmit alternating electric currents over nearly double the greatest distance which they have hitherto been transmitted while using at the transmitting station alternating currents of precisely the same tension, and while using line wire of the ordinary kind. If desirable, the current might be sent over a distance of 150 miles by having two transformers such as I have described. One of these might be placed at a distance of 50 miles and the other at a distance of 100 miles from the transmitting station." It is then suggested that if it is desired to use direct currents, rotary transformers having a ratio of 1 to 1, may be substituted for the transformers.

It has been said that for every electrical condition may be found an analogue in mechanical operations, hence to illustrate the present case it may be well to recall the instance of the embryonic electrician who confidently ad-

vanced the original idea that, as the greater the number of Le Clanche cells in a series, the louder the series would ring a bell, why not, after the same manner, connect several steam boilers in series so that extremely high pressures could be generated without imposing additional strains upon the boilers, thus enabling steam engines to deliver greater power?

After the writer referred to has settled upon the best way to connect steam boilers in series—whether fire door to smoke stack, or mud valve to steam dome; or perhaps, after he has concluded that it would be advisable to connect blow-off to furnace—he may be disposed to enlighten the benightment of the electrical engineering world upon the advantage to accrue from the giving of something for nothing: from the barter of a zero for a zero with its rim off.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

STREET RAILWAY PUBLICATIONS.

The event of the year in street railway circles is the annual meeting of the American Street Railway Association, and so vital have the applications of electricity become to a solution of the problems of local transportation, that the annual convention of the street railway men has, perforce, almost developed into a gathering of electricians. Of course, many are the subjects pertaining to street railways that are without electrical import; but the question of paramount importance—that of motive power equipment—cannot be considered without acknowledgement of the fact that electric traction is far in advance of any other system. Its efficiency is higher, it is used more extensively, and it is in greater favor with the public; all of which explains why there is so much of electrical detail to be found in the proceedings of the street railway association.

It is in the two street railway publications, however, that the greatest interest of the electrical railway world centers, and especially superb are these publications at Convention times. This year the Association meets at Boston, and the August number of the *Street Railway Review* is so replete with articles of high literary merit concerning the city of Boston and environs, as to make it prized by the layman, and so elaborated with descriptions of Boston's chief electric railway systems as to make it invaluable to the electrical engineer. This is the more artistic publication of this year's Street Railway Convention numbers, but the regular September number of the *Street Railway Journal*, which has also been made a souvenir of the Boston Convention, is as well, a most unusual publication in size, in typographical appearance, and in the character and quality of its reading matter. Especially meritorious are its leading articles on "Street Railway Conditions and Financial Results in Metropolitan Boston," which is devoted to a financial analysis of thirty-one street railway properties in and about the city of Boston; "The Boston Subway," in which is described in considerable detail the latest plans of the subway and subway stations as finally carried into effect, and the "Proposed New Electric Elevated Railway in Boston," a brief article on the proposed construction.

As a class, the two street railway publications now so prominently before the electrical and street railway public, are incomparably superior to any other trade papers published, and they are simply models of the highest excellence.

* * *

AMERICAN NEWS FROM A FOREIGN SOURCE.

The London *Electrician* quotes Prof. Thompson as stating that "in the United States nearly every gas works possesses, or is erecting, a carbide plant in order to use acetylene gas as an enricher for the coal or oil gas ordinarily produced."

The truth is that, so far as the portion of the United States west of the Rocky Mountains is concerned, if a single, solitary gas works "posseses, or is erecting," a carbide or acetylene plant of any nature other than for the purpose of laboratory experiment, the fact is unknown. Nor is it known that acetylene gas is used as an enricher by any gas works in America.

* * *

TURNING A NEW LEAF.

The Engineer and the *Scientific Machinest*, published at Cleveland, O., have been consolidated and now appear under the name first given. The publication contains considerable of interest and value to those who have to do with steam generation and use, and has also some aspirations in an electrical direction. It is hoped however, that the new paper will early see the wisdom of breaking away from the chronic inclination so long evidenced by the *Scientific Machinest* to "crib" matter from its contemporaries without giving proper credit therefor.

Transportation

RHEOSTATIC VS. SERIES PARALLEL CONROL.

BY PROF. THOMAS GRAY.

IN the spring of 1896, a number of experiments were made at Louisville, Ky., by members of the senior class of the Rose Polytechnic Institute, of Terra Haute, Ind., on the relative efficiency of the above two methods of controlling the current flowing through the motors of an electric car. In the rheostat method the motors were in parallel, and the total current passed through a rheostat having a maximum resistance of 4.2 ohms. In the series parallel method, the rheostat was first used with the motors in series, and after the resistance had been cut out the next step of the controller lever threw the motors in parallel, and at the same time put each in series with half the rheostat.

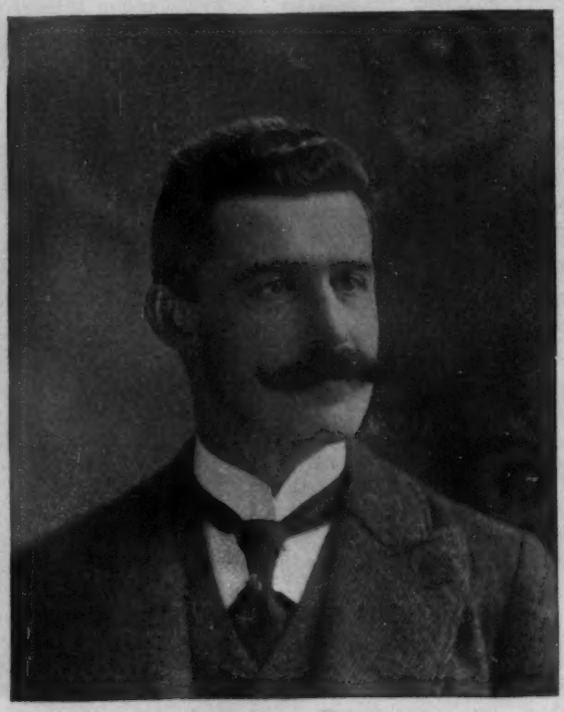
After this, the resistance was cut out, and the two motors left in parallel. The final conditions were thus the same in both cases.

The tests included the measurement by means of an integrating watt meter of the watt hours required to make a round trip of 5.5 miles, the car being stopped forty times during the trip. An autographic record was taken of the variation of activity during the start. The rheostat method gives maximum activity at the initial contact, after which there is a gradual diminution as the car attains speed, combined with the sudden increases as the successive coils of the rheostat are cut out. The series parallel method gives the maximum activity when the motors are first put in parallel, and then after the car has attained a speed of four or five miles per hour. The consequence is, that more of the activity is used for propelling the car, and less in overcoming resistance. There resulted in a comparative economy of from ten to fifteen per cent. under the conditions of the test. The ratio of the work done in starting the car in the two cases, as indicated by the autographic record, was approximately four-fifths. The total weight of the car used was about 15,500 pounds, the watt hours per car mile averaged about 900, and the maximum speed between stops about twelve miles per hour.

Personal

MR. THEO. E. THEBERATH is a native of New Jersey, having been born in Newark on November 22, 1863. After finishing the public grammar schools and a two years' course in business college, the subject of this sketch commenced life in the world of business as an apprentice in his father's factory in Newark, where he learned the various trades in connection with the manufacture of saddlery hardware. It was there, in the electro-plating baths, that an acquaintance with an application of electricity was first had, and this acquaintance has, during the succeeding years, grown to be so intimate that today Mr. Theberath has already earned the justly deserved distinction of being one of the best electrical engineers that has entered the electric power transmission field.

But to revert to his earlier life: Several years were spent in the saddlery hardware factory, when his father gave young Theberath the choice of getting a better education, or of continuing in the saddlery hardware business. This resulted very quickly in his entering the Stevens Institute of Technology, from which he graduated as mechanical engineer in June, 1888. Six months were then spent as assistant instructor in experimental mechanics at Stevens Institute, when, in November, 1888, Mr. Theberath entered the service of the United States Electric Lighting Company, of Newark, N. J., as detail draughtsman. On February 1st, 1889, the United States Electric Lighting Company was absorbed by the Westinghouse Electric and Manufacturing Company. Under the new management, however, the services of Mr. Theberath were retained in the draughting room until April of the same year, when he was placed in charge of the testing department of the Newark factory of the Westinghouse company. A great deal of practical knowledge was obtained in this position in the ensuing four months, the expiration of which was followed by a transfer to the laboratory with general charge of the testing department and all special work of the outside construction department. Some of the work coming under the head of "special" was the installation, in June, 1890, of the first two large generators for the Pittsburg Reduction Company, of Pittsburg, for the reduction of aluminum. This installation consisted of two generators, each having a capacity of 2500 amperes at 60 volts, and, being run in multiple, they delivered a current of 5000 amperes. This was the beginning of the great plant now operated at Niagara Falls by the Pittsburg Reduction Company for the reduction of aluminum.



THEODORE ERNEST THEBERATH.

In February, 1890, Mr. Theberath was engaged in the installation of several Westinghouse plants to operate coal-cutting machinery in the soft coal mines in West Virginia. In August, 1891, he commenced the installation, which he completed within a few months, of the electrical apparatus for the concentration of magnetic iron ore at the mill of the New Jersey Magnetic Concentrating Company, located in the Adirondack mountains, in New York state. This work, in connection with the wide range of experimental work constantly under way at the laboratory, resulted in Mr. Theberath becoming possessed of information and experience of unusual value along technical lines, so that when Mr. Jno. F. Kelly, who was then chief electrician of the Newark branch of the Westinghouse Company, resigned that position in December, 1891, Mr. Theberath was appointed to the vacancy. During the nine months that Mr. Theberath held the chief electricianship of the Newark branch, his time was largely occupied in designing special generators and crane motors.

Believing that the commercial side of the electrical industry extended greater advantages than the engineering side, Mr. Theberath resigned from the chief electricianship of the Newark branch of the Westinghouse company on October 1st, 1892, and immediately entered the employ of the Ansonia Electric Company, of Chicago, as special sales agent for Stanley transformers. On the dissolution of the Ansonia Electric Company, in October, 1893, he entered the service of the Weston Electrical Instrument Company in charge of the standardizing department, where he remained for nearly a year. On August 1st, 1894, he resigned this position to become associated with the New York office of the Stanley Electric Manufacturing Company as engineer and salesman. Just two years thereafter—August 1st, 1896—he was transferred from the New York office to the Pacific Coast agency of the Stanley company at San Francisco, where he will probably remain permanently. Mr. Theberath first came prominently before the electric transmission interests of the Pacific Coast through his electrical engineering services for the Stanley agency in the construction of the transmission plant of the Blue Lakes Water Company, and more recently as electrical engineer for the Yuba Power Company's transmission to Marysville. His paper on "Lightning on Transmission Lines," read before the Sacramento convention of the Pacific Coast Electric Transmission Association, is one of the most able papers ever brought before that body.

Mr. Theberath's chief characteristics are thoroughness and untiring intensity of purpose. He is a close student, a hard worker, and every inch an engineer. More than this, those who are so fortunate as to be numbered among his personal friends—and they are many—will all attest with one accord that "Theby" is among the nobility of charming fellows.

PROF. F. B. CROCKER, past president of the American Institute of Electrical Engineers, president of the Crocker-Wheeler Electric Company, and an electro-technical author of note, was among the recent prominent electrical visitors in San Francisco.

MR. W. L. HONNOLD, of San Andreas, Cal., is to act as manager of the Thorpe Gold Mining Syndicate, at Fourth Crossing,

Calaveras county, and will also continue to have charge of the properties of the California Exploration Syndicate, Ltd., with which he has been connected as superintendent for the past two years.

PROF. ALEXANDER GRAHAM BELL, inventor of the Bell telephone, recently passed through San Francisco en route to Japan and the Orient, and it is probable that he will continue his pleasure trip around the world.

MR. A. P. BREYTON, JR., vice-president and manager of the Pelton Water Wheel Company, has sailed for a three months' trip to Japan and the Orient.

MR. P. F. MOREY, president of the Portland, Or., General Electric Company, recently visited San Francisco.

Transmission

MOISTURE ON HIGH TENSION INSULATORS.

BY LIEUT. W. STUART-SMITH, U. S. N.

AN editorial appearing in the August issue of THE JOURNAL OF ELECTRICITY relative to insulators for high tension lines, and the discussions constantly taking place as to the effect of the hygroscopic quality of glass, impels me to an expression of opinion on the subject. The editorial referred to states: "While, as far as we know, it is yet to be demonstrated that static electricity exerts any appreciable influence on the temperature of transmission insulators towards the dissipation of moisture that may accumulate thereon, it is well understood that the presence of high tension current on the line tends to preserve its insulation resistance."

To be sure, we must have forgotten our early lessons in electricity that we do not realize that the tendency of an electric charge is to prevent the accumulation of moisture on the surface of a charged body and that this tendency is enormously increased with increasing potential.

Don't we remember that so-called "like" electricities repel, and that on any conducting body, a static charge will only be found on the surface — as far from the center as possible; *i. e.*, it will divide itself over the greatest possible surface, thereby causing the tension to become a mininum? Don't we remember that, in a moist atmosphere, it is impossible to maintain a static charge on a body, not because (as is frequently said) the air is thereby rendered a better conductor and the charge passes through it as through a conducting medium, but because moisture, condensing on the surface, forms a new and easily disintegrated surface which the charge occupies because it is of larger area than that formerly occupied?

Right here some one may say, "What has this to do with the matter? The surface of the insulator is not conducting." This is true as long as it is dry, but as soon as moisture condenses to even the smallest extent, it becomes a conducting surface.

The presence of the charge and the tendency to increase the surface area to the largest possible extent, result in a repulsive force between the neighboring water molecules, and if the electric tension is such that this repulsive force between molecules is greater than the forces binding them to each other, they will fly off into the surrounding space, each taking with it a quantity of electricity depending upon its surface. The action will continue until equilibrium is restored between the forces of repulsion and resistance to molecular separation. If the electric charge causing the surface tension is not renewed, the action will very quickly cease, but if constant renewal of the charge takes place, the action will continue until every vestige of moisture disappears. As such constant renewal takes place when the charged surface is that of an insulator carrying a high tension line, it is evident that when the potential of the line is very high, as is the case with modern transmission lines, any moisture present when the potential is applied to the line will quickly disappear, and any further accumulation will be impossible, since dissipation will take place as fast as there is any condensation. The force of repulsion, and hence the rapidity of dissipation, will increase with increasing line potential, and the hygroscopic quality of the surface will practically be nullified when the tension is a little greater than that necessary to produce a rapidity of dissipation equal to the rapidity of condensation. For any given insulator surface, this will depend upon the hygrometric condition of the atmosphere, but with the high potentials now in use for transmission lines, it is probable that no surface will condense moisture as fast as the force of repulsion can dissipate it, even in a fog.

This being the case, the character of the surface is practically immaterial, and glass is at no disadvantage on account of its inherent power of condensing moisture. Its hygroscopic power may be ignored when very high tensions are carried.

The editorial mentioned, states near the close, that the drying is due to the heating action of the static charge, but in reality the drying is the result of the tendency of the charged surface (in this case a film of moistere) to expand indefinitely. The closing statement is that the action is remarkable. So it is; yet it is a natural consequence of previously well known laws of static charges.

THE MECHANICVILLE-SCHENECTADY TRANSMISSION.

THE development of the power of St. Anthony's Falls, on the Mississippi, at Minneapolis, Minn., is followed closely by the utilization of the power of the upper waters of the Hudson river at Mechanicville, N. Y., where an undertaking of no less magnitude has been completed within the past few days. From five to seven thousand horse-power is available at the power house, and the use of high tension current permits of its distribution over a wide territory.

As in the Mississippi, the waters of the Hudson above the present point of development have been to some extent employed by factories using low head turbines for driving their machinery direct, but not until the undertaking just concluded was decided upon had any very serious effort been made to take advantage of the great amount of power which has run to waste for ages down the stream of the main waterway of the Empire state.

It was early in 1897 that the attention of Mr. R. N. King, of Dayton, O., was drawn to this water power, and his long experience with water powers and their development led him speedily to recognize the possibilities which here lay ready to hand. The site is only two miles from Mechanicville, eleven miles from Troy, and eighteen miles from Albany, in each of which towns large amounts of power would, without doubt, find a market. But most important of all, it lay only seventeen miles from Schenectady, where, covering not less than 130 acres of ground, the largest electrical works in the world are operated from an extensive steam plant with which the electrical power from the Mechanicville cataract could readily compete. As a result, and after consultation with the chief engineers of the General Electric Company, in which the necessary assurances were given, Mr. King formed the Hudson River Power Transmission Company.

The hydraulic engineering features of the development were carried out in their entirety by Mr. A. C. Rice, chief engineer; and it may be said that in the complete work as it stands today, little or no departure from the plans laid down by Mr. Rice has been made. As the General Electric Company was to purchase the largest amount of power, its advice as to the electrical equipment was naturally closely followed. The result brought about by the harmonious co-operation of both hydraulic and electrical engineers is a power transmission plant which is in every respect strictly representative of the most modern hydraulic and electrical practice.

At the point chosen for the hydraulic development, the physical conditions make the location an ideal place for a dam and power house. The banks and bottom of the river are of rock, as is Bluff Island, which divides the Hudson into two channels; and here, during the greater part of the year, is water sufficient to produce from 7000 to 10,000 horse-power. The island is about one-third

of the distance across the river from the western bank, the combined width of the two channels being about 1200 feet. The western channel is used for the head and tail races.

In order to make the excavations for the power house and main dams, heavy cofferdams were built across both streams. The work would have been well completed within the time at first specified had not an extraordinary freshet swept away part of the cofferdam, necessitating long delay before work could be resumed.

FIGURE 1.—THE POWER BEFORE DEVELOPMENT.

The rock and shale proved unsuitable for incorporation into the concrete for the dams and foundations, and the broken rock used was brought over a special track from the neighborhood of Schenectady.

The power house starts from and extends out into the river about 215 feet, and is connected with Bluff Island by a concrete dam, twenty-six feet high above the bed of the river. It is ten feet wide on top and eighteen feet wide at the base. The upstream face is vertical and the down stream face is sloping. The top of this dam is at an elevation that the water will never reach, thus, no provision is made to take care of falling water on the down stream side, but the dam is provided with four arched waste gates four feet wide and six feet, nine inches high, operated in the same manner as those in the main dam.

The main dam is on the eastern side of the island. It is built entirely of concrete, as indeed, is the entire construction with the exception of the upper walls of the power house. The upstream face is vertical, the downstream face is curved and provided with a horizontal apron fourteen feet wide, which throws the falling water off horizontally, and thus effectually prevents wash or scour of the toe of the dam. The dam is sixteen feet high above the river bed, eight feet thick immediately through the crest, sixteen feet thick through the base, and thirty feet thick through base and apron. The dam is set between massive abutments anchored to the rock sides of the river bank and island. The eastern abutment is twenty feet long, twenty-six feet high above river bottom, sixteen feet thick at the top and thirty-four feet wide at the base; the western abutment is one hundred feet long, the other dimensions being similar to those of the eastern abutment. The length of the spillway between abutments is three hundred feet. In the western abutment are twelve arched waste gates of ample proportions. Each gate is four feet wide and six feet high, and is opened and closed by a heavy iron hoist operated by rack and pinion. The eastern dam is practically a solid rock wall capable of resisting any flood. It was severely tested in the spring of 1898 when a flood of extraordinary proportions came against it; yet, notwithstanding the fact that the dam was green, the flood in no manner injured it. To prevent any floating rubbish, ice, or logs reaching the rocks or choking the waste gates, a floating wooden boom stretches from the western end of the spillway diagonally for a distance of four hundred feet, to the edge of the normal river bank, and then for a distance of one thousand feet to the main embankment of the Mechanicville highway. It is anchored to a line of stone filled cribs. Between the west end of the power house and the Mechanicville highway a broad roadway has been built of earth and slate rock. To avoid any possibility of water finding its way through the embankment in case of very high water, a concrete core was put in the center, starting at the solid rock and finishing two feet below the surface of the road. The embankment forming the roadway is forty feet wide on the top, 124 feet at the base, and 18 feet high at the deepest point. The power house lies between the west bank and the short concrete dam, nearly filling the space between the island and the west bank of the river. It is practically a continuation of the dam, and, like the main dam, is of concrete with the exception of the upper walls. Its construction is of the most substantial character, the foundations are carried down to the bedrock, and the house is carried on heavy steel box web girders resting upon steel I beam columns. The latter are imbedded in concrete walls carrying arches which form the floor of the generator room and the floor on which the wheel flumes rest. The walls form a separate and distinct tail race twenty-two feet wide for each set of turbines from which the water may be shut out at will.

FIGURE 2. MAIN DAM AND WASTE GATES.

The house is divided into two parts by a thick head wall. The

upstream part contains wheel chambers for seven 1000 horse-power wheels, of which five only are at present occupied. The downstream portion contains the wheel governors and the electrical apparatus. The length of the power house proper is 257 feet, 6 inches; the width of the dynamo room between head wall and south wall is thirty-four feet, and the width of the wheel chamber portion is thirty-two feet, six inches. The total width of the

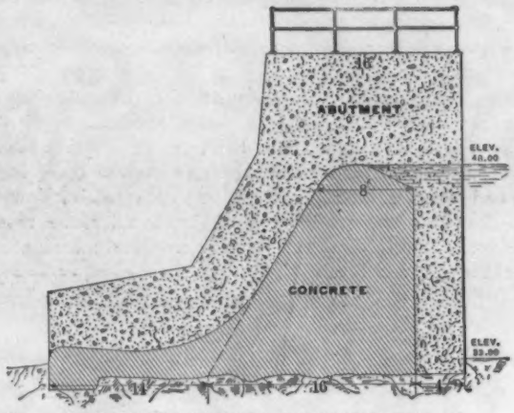


FIGURE 3.—SECTION THROUGH MAIN DAM.

power house is sixty-six feet, six inches. At the western end an L extension runs upstream eighty-seven feet, five inches long and forty-four feet, ten inches wide. This portion of the power house is of brick. A retaining wall runs down stream from the power house along the western bank a distance of fifty feet. The western stream running between the bank and the island forms the forebay, three hundred feet long. The main tail race is 205 feet wide, and joins the main stream 750 feet below the power house.

Arched chambers are provided for seven main wheels and two exciter wheels. Each main chamber is thirty-two feet, six inches long, twenty-two feet wide, and seventeen feet five inches high, and is provided with two six-foot manholes. Each exciter wheel chamber is thirty-two feet, six inches long, seventeen feet, five inches high, and ten feet wide. The head wall of the chambers is six feet thick; the wall on the upstream and on both sides is three feet thick. In the head wall of each main chamber is set a heavy cast-iron cover through which the turbine shaft passes in a water-tight packing box, carrying the ring oil bearing for the horizontal turbines, each main turbine consisting of two pair of wheels, which at the normal speed of 114 revolutions, is rated at 250 horse-power. The total power of each set of turbines is, therefore, 1000 horse-power. Five units are now in position; the two additional turbines will be installed shortly. The head under which the water wheels are operated is eighteen feet.

The turbines for the exciters consist of three eighteen-inch cylinder gate wheels, having, at 259 revolutions per minute, a total of 300 horse-power. The quarter turns and packing boxes of these wheels are brought through the wall beneath the station switchboard.

Two draft tubes lead from each main turbine, the forward tube descending straight into the tail race beneath the power house, the rear or upstream tube curving and flaring downward and outward. Each tube is nine feet, six inches in diameter at the bottom. Two draft tubes are also allotted to each set of exciter wheels, the setting following a similar arrangement. The rear tube is four feet in diameter and the forward tube three feet.

The speed of each set of main wheels is regulated by an electro-mechanical governor, mounted on a platform directly over the turbine shaft, and between the head wall and the generator.

The use of electricity renders the mechanism of this governor extremely sensitive and effective, and the gates can be entirely opened or shut, should the full current be thrown on or off, in six seconds. The driving pulley is replaced by a rawhide pinion giving a rigid connection between the governor and the wheel, and making 400 revolutions per minute. The speed may be increased to shut off or throw on in less than six seconds, if necessary. The governor is the same as that now in use in many of

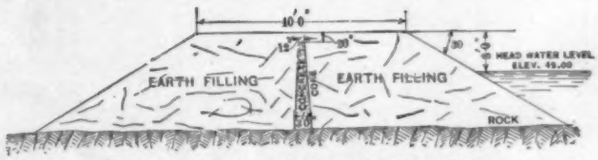


FIGURE 4.—SECTION THROUGH EARTH EMBANKMENT.

the most important electric power transmissions in this country, including those of Columbia, S. C., Polzer, N. C., Lachine, Que., West Kootenay, B. C., Montmorency, Que.

The governors controlling the exciter wheel gates rapidly bring the speed to normal when changes are neither frequent nor heavy. They are especially adapted to the regulation of water wheels driving exciters, and are provided with adjustable stops which

FIGURE 5.—UPSTREAM SIDE OF POWER HOUSE WITH FOREBAY.

shaft. The saving in space effected by the new arrangement of housing and coupling together of the turbines has tended to diminish considerably the size of the power house. A twenty-ton crane runs the entire length of the dynamo room.

In front of the wheel chambers, and running the entire length of the power house, is a trash rack of steel bars supported on a framework of steel channel and I beams. This rack effectually prevents the access to the wheels of any rubbish or floating material that may escape the boom.

The main wheel plant consists of ten pair of forty-two-inch limit the hoisting action on the gate as soon as the gate is fully open.

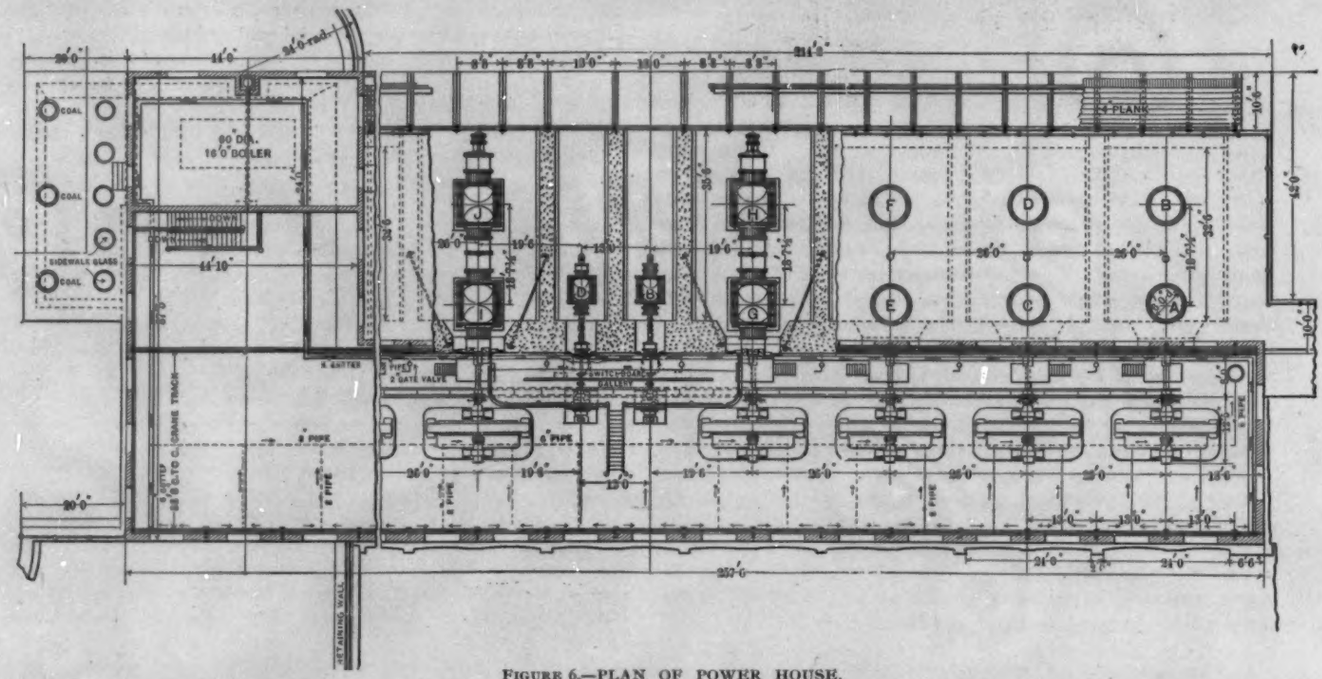
The dynamo room is a spacious chamber well lighted by windows on all sides. It is 255 feet long and 34 feet wide, 30 feet, 5 inches in the clear from floor to roof truss, and 22 feet from floor to crane. The ultimate generator capacity of the station is 7000 horse-power in seven generators, each of 750 kilowatts capacity, of which five have been installed and are now running. They are unitooth, three-phase, forty pole, 750 kilowatts, 114 revolution, alternating current machines, having revolving fields and station-

ary armatures, and wound to deliver thirty-six amperes of current at a periodicity of thirty-eight cycles and a pressure of 12,000 volts to the transmission lines. They are arranged for operation in parallel at constant voltage. By using the revolving field type of generator and thus securing this pressure directly from the machine, the use of step-up transformers to raise the voltage for transmission purposes is avoided. As the current is to operate synchronous and induction motors, to operate lights, and to be converted into direct current through rotary converters, a frequency of about 40 cycles was selected as most suitable for the different conditions required.

The alternators are similar in their main characteristics to those successfully used in the development of the power of the Lachine Rapids at Montreal. The armature frame or ring is of the box type, fifteen feet, four inches in diameter, and thirty-six inches wide. It is bolted to a base eighteen feet, two inches long by ten feet wide, along which it may be moved parallel with the shaft, in order that the revolving field spider and poles may be uncovered should occasion arise. The armature winding is protected

The switchboard erected on a gallery on the north wall of the dynamo room, is built up of nine highly polished panels of blue Vermont marble, each panel seven feet, six inches high, three feet wide, and two inches thick. Of these nine panels, five are used for the generators and two for the feeders; one is the total output panel, and the last is for the control of the exciters. The generator panels occupy the left side of the board, and room on the gallery is left for two additional panels. The feeder panels are on the right side; the total output panel is between these and the generator panels, and the exciter panel is the third panel from the left hand end of the board.

Each generator panel is equipped with the following instruments: One inclined coil alternating ammeter reading to 75 amperes for the generator, and one direct current ammeter reading to 150 amperes for the field. Above each of these is a pilot lamp and between each pilot lamp a synchronizing lamp. Beneath the two ammeters is an inclined coil voltmeter reading to 15,000 volts, and beneath this instrument are three single blade, doube throw, quick break, high tension switches, each mounted


COAL
COAL
COAL
SIDEWALL GLASS
90 DIA.
16'0" BOILER
R. GUTTER
8" PIPE
2 GATE VALVE
8" PIPE
6" PIPE
8" PIPE
8" PIPE
8

two strong spiral springs encircling this pivot. As soon as an increase of current in the line melts the fuse, its two halves are instantly pulled apart, and thus the formation of an arc between the two halves is prevented. The melting of the fuse can only occur in a small chamber protected by wooden blocks. The whole device is covered by two vertical wooden boards. Sliding in between these wooden boards in vertical slots, are fibre shields

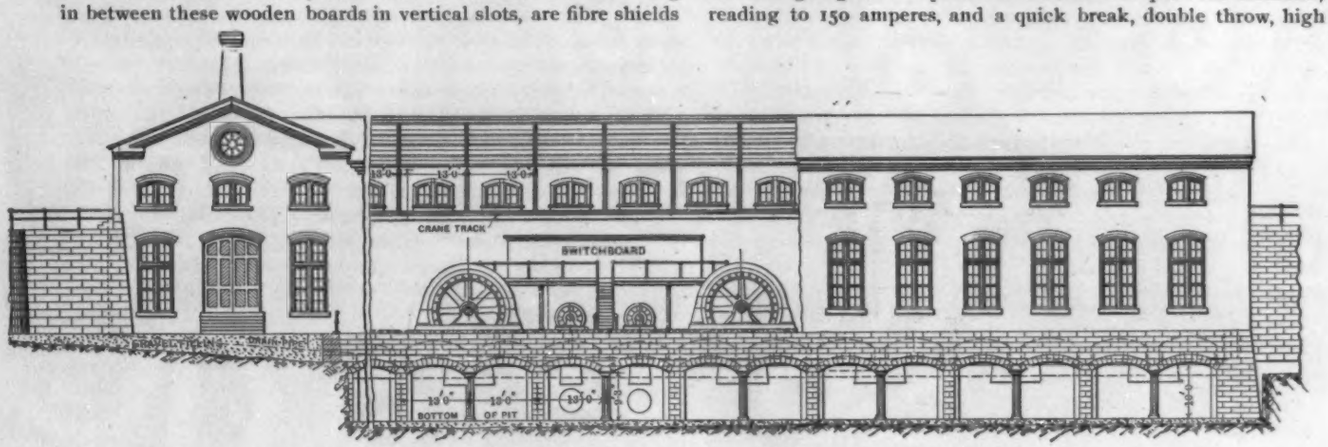


FIGURE 7.—SIDE ELEVATION OF POWER HOUSE, LOOKING UPSTREAM.

intended to prevent arcing over between the two arms after the separation of the two halves of the melted fuse. The two wooden blocks and fibre shields are held in position by four screws. The whole fuse block is inserted in the line simply by pushing the two blade-like copper contacts between the clip contacts, which are connected by solid copper rods to the 'bus bars. The wooden boards protecting the fuse are 10⅛ inches long by 6⅜ inches wide. The corrugated rubber pyramids on which the contacts are

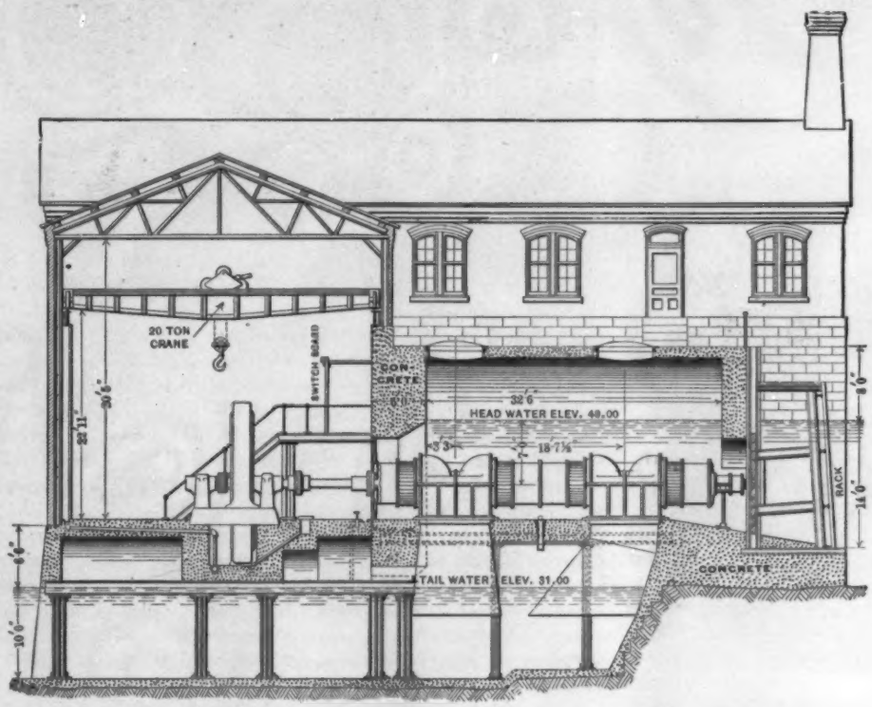


FIGURE 8.—SECTION THROUGH MAIN WHEEL CHAMBERS.

mounted are 3¼ inches high. The field rheostats are hung beneath the gallery, and are operated by hand wheels on the gallery and bevel gears below it.

The exciter panel controlling the two direct current exciters carries two pilot lamps, two circular dial ammeters, each reading to 1000 amperes, one volt-meter reading to 150 volts, one four-point pressure switch, one synchronizing switch, two 800 ampere triple blade, double throw equalizer switches, and two packed card rheostats.

The two feeder panels are similar to each other in every respect. Each outgoing line is provided with an independent ammeter, reading to 150 amperes, and a quick break, double throw, high tension switch, similar to those on the generator panels, and similarly mounted on the board. Mounted also on corrugated hard rubber pyramids are the six circuit breakers or automatic plunger switches.

These high potential plunger switches consist simply of long copper rods sliding in hard rubber tubes. The upper ends of the rods reach into small rings in contact with which they are held by a lever catching a small rubber head on the lower end of the copper rod. This lever is held in place by a spring and is released by moving a rocker arm on the back of the switchboard. The moment it is released a spiral spring pushes the copper rod downward, and by this movement, aided by the action of gravity, so suddenly is the contact broken that arcing between the rod and the ring is prevented. The rocker arm controls the three switches for each set of 'bus bars, so that they may be all released at once. On the upper part of each feeder panel at the back, is a current transformer for each outgoing line, two recording single-phase wattmeters, each reading to twenty-five amperes and 12,000 volts, and two potential transformers. On the front of the output panel are two Thomson recording wattmeters for balanced three-phase circuits, each reading to 300 amperes and 12,000 volts, and twelve triple pole, single throw 100 ampere switches with fuses for the lighting circuits. On the back are four potential and two current transformers. The lightning arresters are of the GE. short gap type. Arresters of this type have been installed on nearly all of the most important long distance transmission lines in this country, and have proved a most satisfactory protection against damage by lightning. The principle on which this arrester operates is very simple. It allows the passage of any high potential discharge, but effectually prevents the alternating current from following and maintaining

an arc. The gap spaces in the lightning arresters at Mechanicville are very small—about $\frac{1}{13}$ inch—each space lying between two solid metal cylinders two inches in diameter and two inches long. A low non-inductive graphite resistance is placed on the circuit, and the action of the arrester, therefore, is dependent upon the cooling effect of the large metal cylinders, aided by the

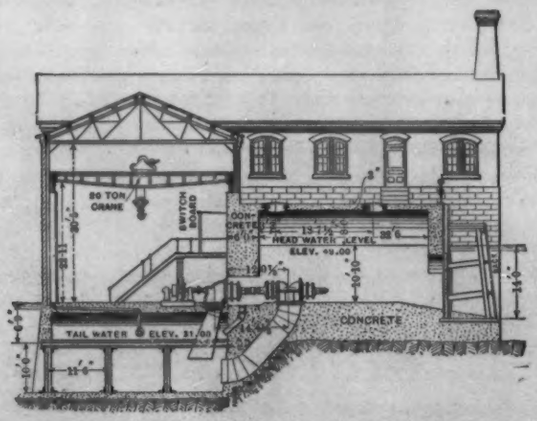


FIGURE 9.—SECTION THROUGH EXCITER WHEEL CHAMBERS.

reversal of the alternating current and the introduction of the non-inductive resistance. The line is protected by double pole 2000 volt arresters, connected six in series to give the necessary number of spark gaps. There are three sets of these. One at Mechanicville, grouped around the first transmission pole in a small house fifteen feet square, one set on the Schenectady side of the Glenville bridge, where the overhead pole line connects with the underground cable, and the third at the works.

The lead covered leads from the generators are taken out at the base of the machine and are laid in ducts in the floor. Rubber covered wire is used for the field connections. The cables rise on a frame from the duct to the floor of the gallery through which they rise to the board. From the back of the board the line wires rise to supports bolted to the I beam on the north wall, which supports one of the crane runways. The lines run along the north and west walls and pass out to the poles through a blind window over the door of the power house.

The line from Mechanicville to Schenectady is the only one at present laid down. It consists of three No. 000 B. & S. bare wire,

FIGURE 10.—A MAIN WHEEL CHAMBER.

this large gauge being employed in order to give the line as high self-induction as possible. This insertion of self-induction in transmission lines is a departure from earlier practice. In cases where synchonizing apparatus is used, self-induction is now considered necessary, and is artificially brought into the line in the shape of reactive coils in cases in which the natural self-induction is too small. The circuits are carried on poles thirty to sixty feet long, and all eight inches in diameter at the top. Each pole carries one cross arm, on one side of which are two porcelain insulators of the triple petticoated type, a third being on the other side. For lightning protection, a barbed wire frequently grounded, runs along the tops of the poles.

The line takes a westerly direction to East Glenville and then due south to Schenectady. At the end of the Glenville bridge over the Mohawk—the town limits—it is carried down to the ground and connected to three cables of No. 1 gauge stranded copper insulated by one-quarter inch rubber and $\frac{3}{32}$ lead sheet laid in terra cotta conduits. These cables run seventeen hundred feet along Washington avenue, rise to poles again through Rotterdam street to the Erie canal, and along the canal to a point directly opposite the General Electric company's power station. They then cross the canal and enter the works.

The introduction of this transmitted electrical power into the factory will work a considerable change. At present all the machinery is driven by electric motors, while the testing department demands an independent supply of current for the work it carries on. There are at present, therefore, two distinct generating plants. The 550-volt motors in the testing department are supplied from an engine driven multipolar generator of 500 kilowatts capacity, while a smaller engine drives a number of exciters which

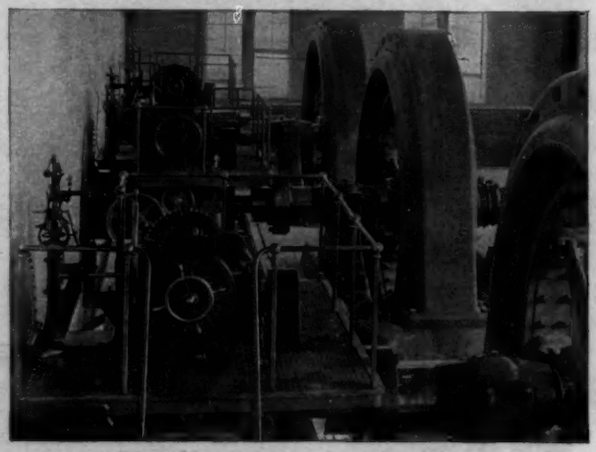


FIGURE 11.—MAIN WHEEL GOVERNORS.

allow of independent control of the excitation of all machines in this department. The factory is operated by a number of 250-volt motors running on the same circuit as the factory lights. These motors will not be changed, and the steam plant which supplies them will be retained as a reserve. The electric power plant superceding the present steam plant at the works will, therefore, consist of two synchronous motors, one of 500 kilowatts, the other of 100 kilowatts, and three 400-kilowatt rotary converters—the synchronous motors for the testing department, the converters to supply current to the factory motors.

The large engine driving the 500-kilowatt multipolar generator is superceded by the 500-kilowatt synchronous motor. This is a twelve pole, 400 revolution machine of the revolving field type, wound directly for 10,000 volts. The small engine driving the exciters is replaced by the 100-kilowatt synchronous motor, and an eight pole, 600 revolutions per minute revolving field machine, similarly wound. This disposition renders this department independent of everything but the speed of the Mechanicville generators, which will be kept as nearly constant as possible.

The three rotaries supplying 250-volt current to the factory motors, are ten pole, 400-kilowatt, 480 revolutions per minute machines, having two commutators and two sets of collector rings connected to independent windings on the armatures. They receive the three-phase current from independent secondary coils of the same set of air-blast transformers. When connected in

multiple they furnish current at normal pressure of 250 volts, but as they may be called upon to furnish current to the testing department in case the demand exceeds the supply from the synchronous motor driven machine, they may be connected in series to give 500-volt current, operating in parallel with the railway generator driven by the synchronous motor in the testing department.

The rotaries are operated in parallel, and all the factory motors, the factory railway, and all the factory lighting on the system is operated from the same direct current circuit. The latter is the Edison three-wire system, the neutral wire of which is secured by connecting the transformers for the rotaries in Y with their secondaries, and bringing to the neutral a lead from their common connection.

Synchronous motors were selected in preference to induction motors on account, first, of their more constant speed and greater efficiency; second, because they do not produce lagging currents. In addition, the phase displacement and power factor may be controlled as desired by means of control of the field excitation.

Synchronous motors of the revolving field type and of good design, are self-starting even under heavy load; and will easily carry two or three times full load without falling out of step for a time limited only by the heating of the motor.

To make the entire works system self-regulating in the direct current distribution, and as far as possible independent of hand regulation, the rotary converters are given a shunt field and a powerful series field, so joined together that the machines operate as one unit. With constant voltage in the generating station at no load, the counter electromotive force of the rotaries as given by their shunt field, is below the impressed electromotive force, and a lagging current is produced. The self-induction of the lines is thus in opposition to the voltage, which is so reduced as to give 250 volts at the commutator brushes of the rotaries. As the load increases, the counter electromotive force of the rotaries rises from the series field, until at full and over-load it is greater than the impressed electromotive force and the current becomes leading. The electromotive force of self-induction of the lines is then brought partly in phase with the voltage which is increased so that in spite of the increased line current, and consequently increased energy loss in the line, with constant generator voltage, the same voltage is produced at the commutator brushes of the rotaries at no load as at full and overload. This control is, therefore, automatic in every way, and did the synchronous motor not take current over the same line in varying quantities, it would suffice. To render this control perfectly automatic, therefore, small series transformers are inserted in the lines leading to the synchronous motor, feeding a small synchronous motor generator controlling the shunt field of the rotaries. By the combined action of their shunt and series fields, the voltage is automatically maintained constant at the commutator brushes of the rotaries, and no hand regulation is required beyond that of readjustment in case the number of rotaries in operation is changed.

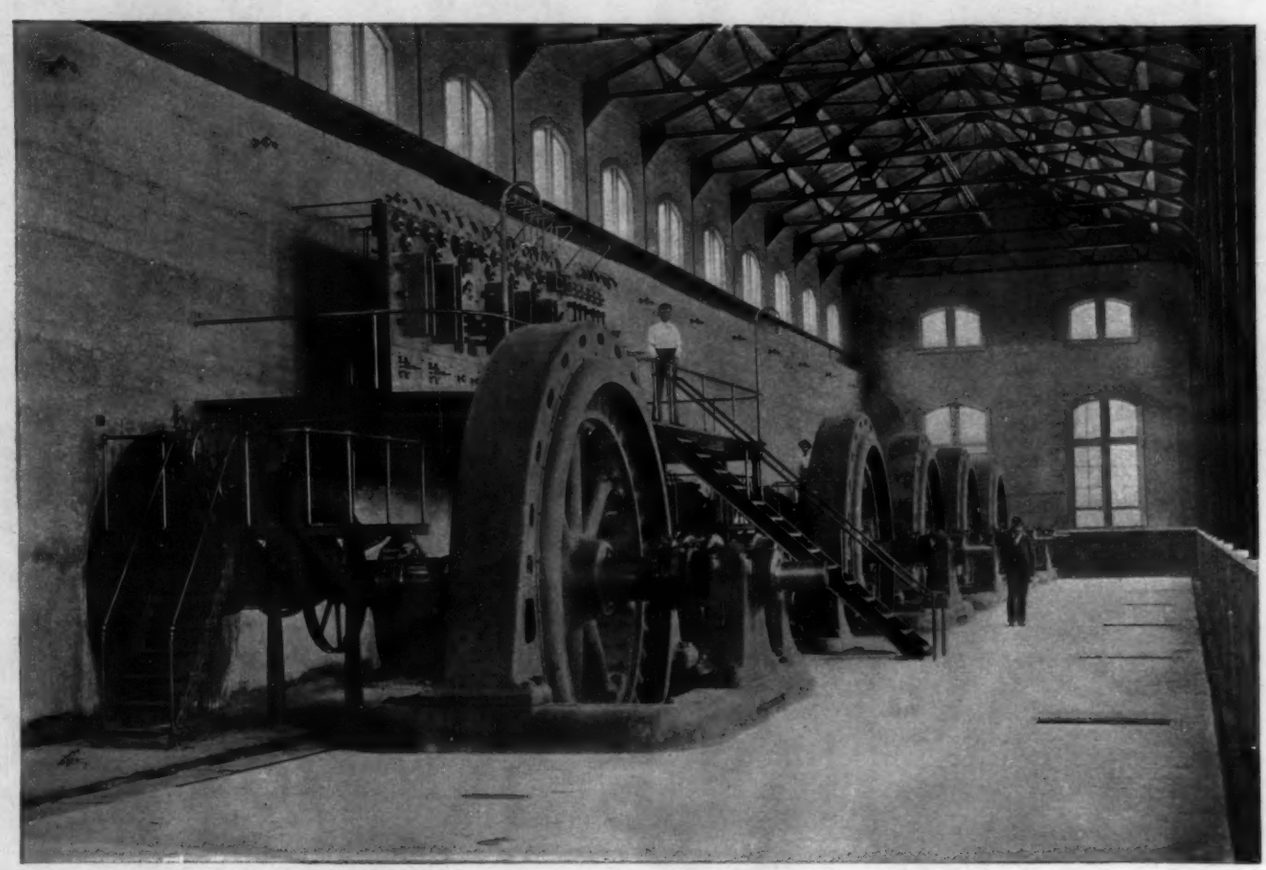


FIGURE 12.—INTERIOR OF POWER HOUSE. DYNAMO ROOM.

The Baltimore and Ohio Railroad is about to indulge in an experiment of using the telephone for long distance communication. Work will begin in a few days on the construction of two new copper telegraph lines between Baltimore and Pittsburg, 340 miles, and they will be so arranged that when the necessity arises they will be available for telephonic communication. One of the wires will be extended as far as Newark for telegraphic use.

A picture of an interesting Baltimore and Ohio Railroad building was reproduced in a recent issue of *Truth*. It is the station at Mount Clare, Baltimore, and it is noted as being the location of the first telegraph office in the world. It was from this building that Professor Morse sent his celebrated message in 1844 to his friends in Washington, forty miles away.

Trade Literature.

(Catalogues mentioned in this department will be mailed gratuitously on application to the concerns publishing them. When writing, mention THE JOURNAL OF ELECTRICITY. Where addresses are not given, they may be found through refereuce to the Advertisers' Index on page iii.)

A twenty-page pamphlet, illustrated, descriptive of the Morton-Wimshurst-Holtz static machine and accessory apparatus for radiography and the therapeutics of static electricity. Dr. Cyrus Edson's ozone inhaler is also described. *A. E. Brooke Ridley, San Francisco.*

"Lightning Arresters," (No. 9061). An exquisite brochure in two colors, illustrative and descriptive of lightning phenomena, and the means adopted by the General Electric Company to afford protection against it. All kinds of electric service are considered. Thirty pages. *General Electric Company.*

"White Lead, Colors, Paints and Chemicals." A substantial ninety-six-page descriptive catalogue and price list of all materials, chemicals, and ingredients used in paints and painting; in brief, it is a lexicon of the art of painting, and, as such, it appears to be indispensable. *Harrison Bros. & Co., (Inc.) Philadelphia.*

"One Quarter of a Million Horse-power of Polyphase Electric Transmission Apparatus." Essentially a list of the principal electric lighting and power plants using the polyphase apparatus of the Westinghouse company, and aggregating over 306,000 horse-power. Illustrated with various types of apparatus. Twenty-four pages. *Westinghouse Electric and Manufacturing Company.*

"The Hunt Cable Railway for Handling Coal and Merchandise," (No. 9803) and "The Hunt Automatic Railway," (No. 9806). Freely illustrated descriptive pamphlets of eighteen and twenty-four pages respectively, showing the perfection which has been reached in the handling of coal at railway terminal points, or at points of consumption. Testimonials are incorporated. *The C. W. Hunt Co., 45 Broadway, New York.*

A fifty-six page pamphlet illustrating some thirty pieces of work of the nearly 600 contracts executed by the concerns named for railway and highway bridges, piers, docks, dredging and harbor improvements, flumes, dams, pipe lines, coal bunkers, and structural iron and steel work. A very convincing catalogue. The *San Francisco Bridge Company, 42 Market Street, San Francisco,* and the *New York Dredging Company, World Building, New York City.*

"The General Electric Company at Omaha." A neat thirty-two page brochure, fully illustrated, for distribution at the Trans-Mississippi Exposition at Omaha. As all the machinery used to light the grounds and buildings of the Trans-Mississippi Exposition, and to supply the power, was furnished by the General Electric Company, the types of apparatus shown in the brochure enable the visitor readily to identify each type as he meets with it in the exhibit, or in any part of the working plant itself. *General Electric Company, San Francisco.*

A 1000-HORSE-POWER INDUCTION MOTOR.

The municipal pumping station of the city of Geneva is being equipped with a two-phase induction motor from the works of Messrs. Brown, Boveri & Co., of Baden, Switzerland, and having a capacity of 1000 brake horse-power. It is a ten-pole machine, running at 544 revolutions per minute, weighing twenty-seven tons, and supplied with two-phase current at 2500 volts and forty-six cycles. The circuits of the rotor are brought out through the hollow shaft to three contact rings, for the use of a separate starting resistance in the secondary.

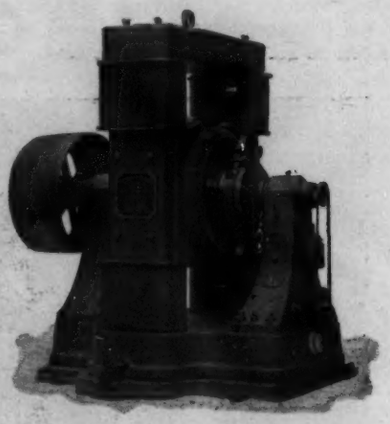
Messrs. Edgecomb and Fox, in a recent paper read before the London Institution of Electrical Engineers, give the following figures for the relative weight of copper for a given maximum voltage: Direct current, 100; single-phase, 200; two-phase, four wires, 200; two-phase, three wires, 291; three-phase, 150.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

THE LATEST FORT WAYNE ARC DYNAMO.

A DECIDED improvement in the efficiency and general qualification of the modern arc lighting dynamo is embodied in the latest machine that the Fort Wayne Electric Corporation has put upon the market, and which is, without doubt, representative of the highest attainment yet achieved in the building of arc machines. It is technically termed the "9 B" arc machine, and it is run at a speed of 725 revolutions per minute, at which it delivers a current of 9.6 amperes at 6500 volts maximum, or 125 lights of 2000 nominal candle power. When wound for 1200 candle power arcs, it is capable of operating 160 lamps successfully. The "9 B" machine will operate on all loads sparklessly; its temperature never rises over thirty degrees above that of the room, which is very low indeed. The weight of the machine is 8343 pounds, the armature alone weighing 1565 pounds, and the dynamo is constructed with reversible regulator and removable field coils. Its efficiency is the highest yet secured in arc machines, for no other arc dynamo can equal the following, which is the record of the "9 B" machine expressed in commercial efficiencies: Full load, 90 per cent.; three-quarter load, 87.5 per cent.; one-half load, 82 per cent.; one-quarter load, 69 per cent.



Further information will be given on application to the San Francisco office of the Fort Wayne Electric Corporation, 18 Second street.

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